Scrubbing of US ATLAS Liquid Argon (LAr) Calorimeter Phase II Upgrade Planning

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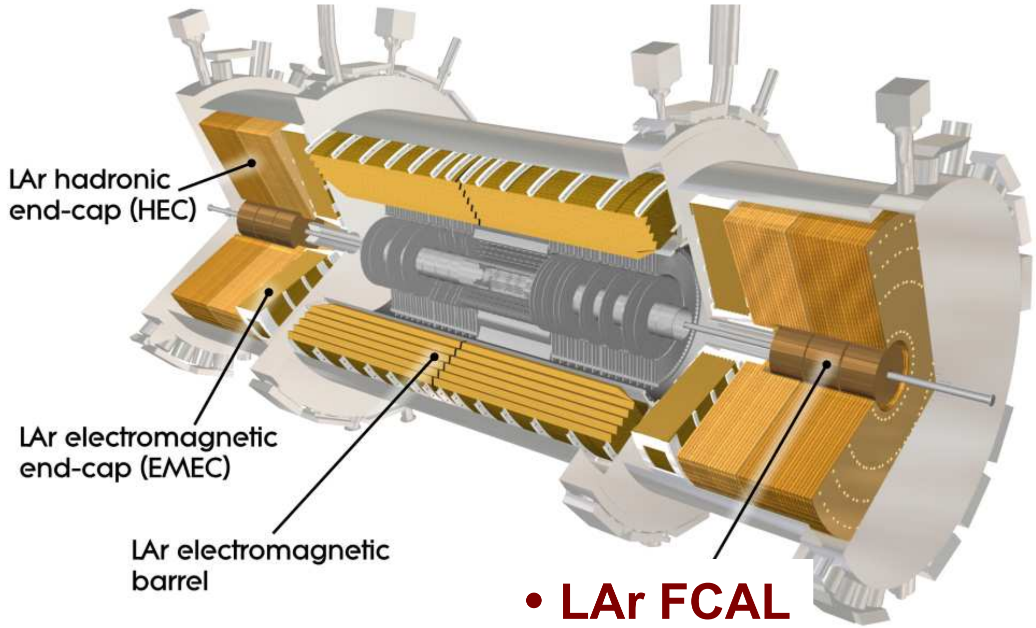
LAr Phase II Upgrade Project

• Readout Electronics



• LAr FCAL

ATLAS LAr Phase II Upgrade:

- Replace the LAr readout electronics
- Modify the forward region, including:
  - possible new (s)FCAL (or miniFCAL)
  - possible new forward precision timing detector

Some ATLAS LAr Milestones

- Initial Design Review (IDR)
  - second half of CY 2016

- Technical Design Report (TDR)
  - second half of CY 2017

- Another very important date
  - decision on sFCAL (and maybe also HGTD?) expected by July 2016

WBS Organization

- WBS was until recently organized around activities at L3, with different institutions at L4
  - Different tasks under L4 are, at least for now, each given separate subtasks for Design, Prototype and Production phases
- After recent Phase II management meeting, I proceeded to propose a reorganized WBS structure, with institutions at L3 and activities at L4
  - Have iterated this new scheme a couple of times with Chuck
- A recent change is that I have introduced a new Activity, “System Integration”, to collect the BNL efforts on FE and BE electronics (except for PA/shaper)
  - This change allows a cleaner DOE/NSF separation, with the FE and BE deliverables falling under NSF scope, and the BNL work accounted separately
  - Latest WBS structure is attached to Indico
- For today, spreadsheet is still organized according to original scheme
  - Actually, is handy for now to see what resources are required for what activity, but will need to change later to new WBS structure

US LAr Activities and Institutions

1. sFCAL (or LAr MiniFCAL)
   - U Arizona
2. FE Electronics
   - Columbia, U Penn, SMU, UT Austin, BNL
3. BE Electronics
   - Stony Brook, U Arizona (MSU, U Oregon)
4. System Integration
   - BNL
5. HGTD
   - UCSC, U Penn, U Iowa, SLAC

(s/Mini)FCAL Core Costs (from SD)

Table 19. CORE costs for the LAr Calorimeter upgrades in the forward region. Costs for a MiniFCal are only due if a high-granularity sFCal will not be implemented and only under well-defined conditions (see Sec. V.4.4).

WBS ID	Upgrade Item	Reference [kCHF]	Medium [kCHF]	Low [kCHF]
3.2	**High-granularity sFCal**	**10,033**		
3.2.1	sFCal1	1,381		
3.2.2	sFCal2	2,567		
3.2.3	sFCal3	2,480		
3.2.4	Cold cable harnesses	995		
3.2.5	Plug	115		
3.2.6	Cooling loops	28		
3.2.7	Cryostat modification	399		
3.2.8	Structural tube, cone, bulkhead	118		
3.2.9	Feedthroughs and signal cables	778		
3.2.10	Front-end and back-end electronics	771		
3.2.11	Detector support and tooling	402		
3.4	**LAr/Cu MiniFCal**			**907**
3.4.1	Detector and Cryostat			125
3.4.2	Warm tube, Moderator, Insertion			330
3.4.3	Electronics and HVPS			285
3.4.4	Module 0			167
3.5	**Si/Cu MiniFCal**			**3,573**
3.5.1	Cu absorbers			30
3.5.2	Sensors and on-detector electronics			1,001
3.5.3	Front-end readout			713
3.5.4	Back-end readout			1750
3.5.5	Services			80

sFCAL

- For sFCAL, discussion of construction responsibilities is quite advanced, with a collaboration that includes US, Canada, Germany, Russia

- As for original FCAL, U Arizona proposes to produce sFCAL1 modules, and also cold electronics for all sFCAL modules

- Construction responsibilities not yet discussed in case (much cheaper) MiniFCAL option is adopted, but U Arizona would be involved in case of LAr MiniFCAL

- sFCAL vs MiniFCAL decision milestone now listed (in SD) as “mid-2016”

- Cost estimate for US contribution is $5074k for sFCAL
  - Would reduce to ~$1000k(?) in case of LAr MiniFCAL (and zero if no FCAL changes)

Status of sFCAL Cost Estimate

- The sFCAL tasks are the same as done by U Arizona in the original construction
  - Apart from thinner gaps, the sFCAL1 modules have the same structure as the FCAL1 modules built in Tucson

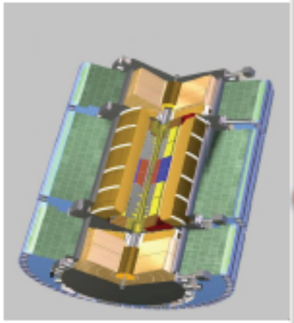
- Effort required, and associated cost, are well understood

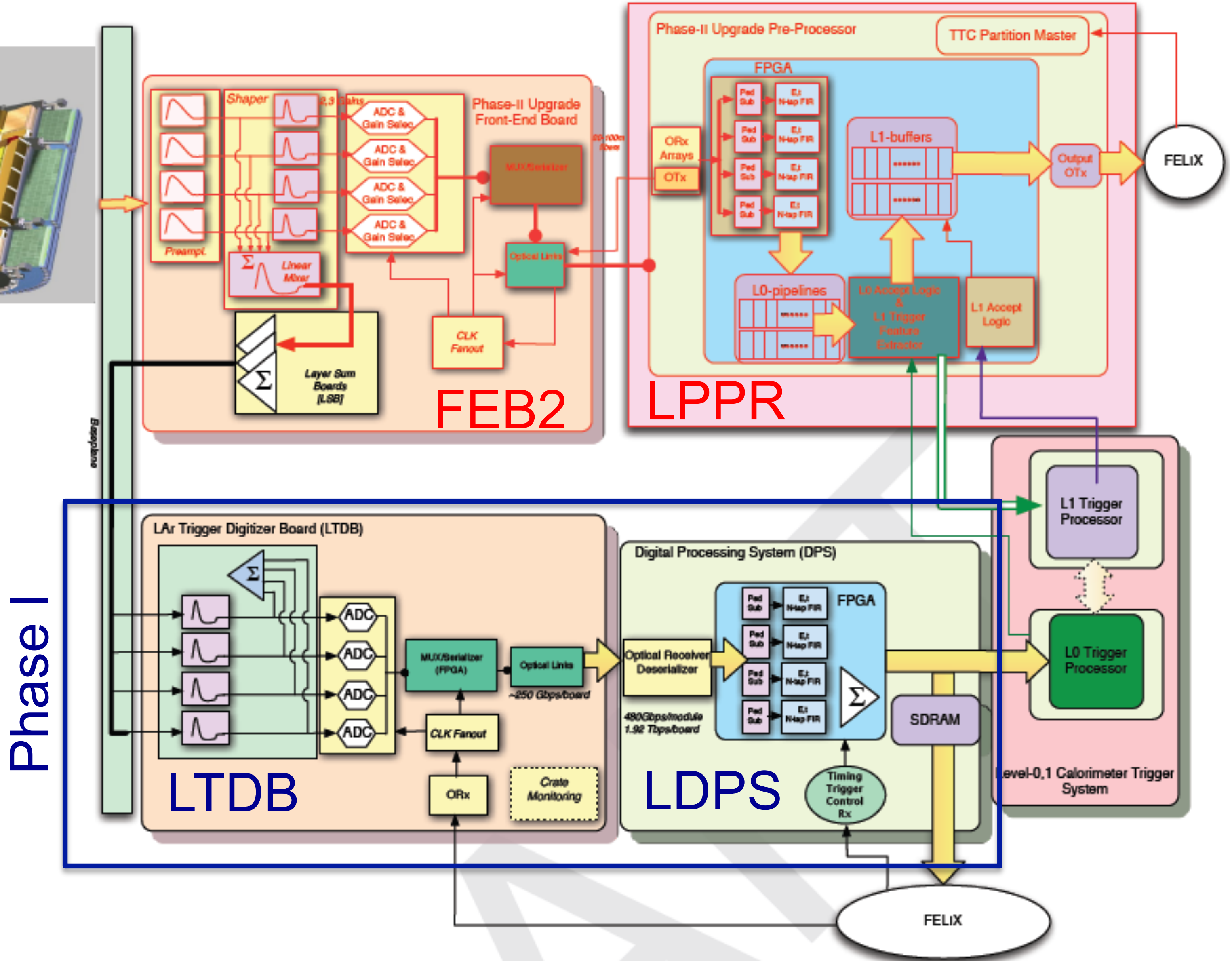
Description	AY k$	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	Total	FY20-FY24
FCAL	Total	128.621	169.336	157.838	1,738.827	1,864.196	700.062	538.673	232.616	-	5,530.168	5074.374
	Labor	103.621	144.336	92.838	256.827	309.196	390.062	329.673	152.616	-	1,779.168	1438.374
	Material	20.000	20.000	55.000	1,460.000	1,540.000	300.000	200.000	70.000	-	3,665.000	3570.000
	Travel	5.000	5.000	10.000	22.000	15.000	10.000	9.000	10.000	-	86.000	66.000
	CORE	-									-	0.000
	FTEs	0.900	1.200	0.800	2.750	3.500	4.850	4.200	1.800	-	20.000	17.100

- John Rutherfoord has prepared a draft BOE, which is on Indico

- For comparison, the Actual Costs during the original FCAL construction were:
  1013k (Labor), 1945k (M&S), 246k (travel), for a total of 3205k

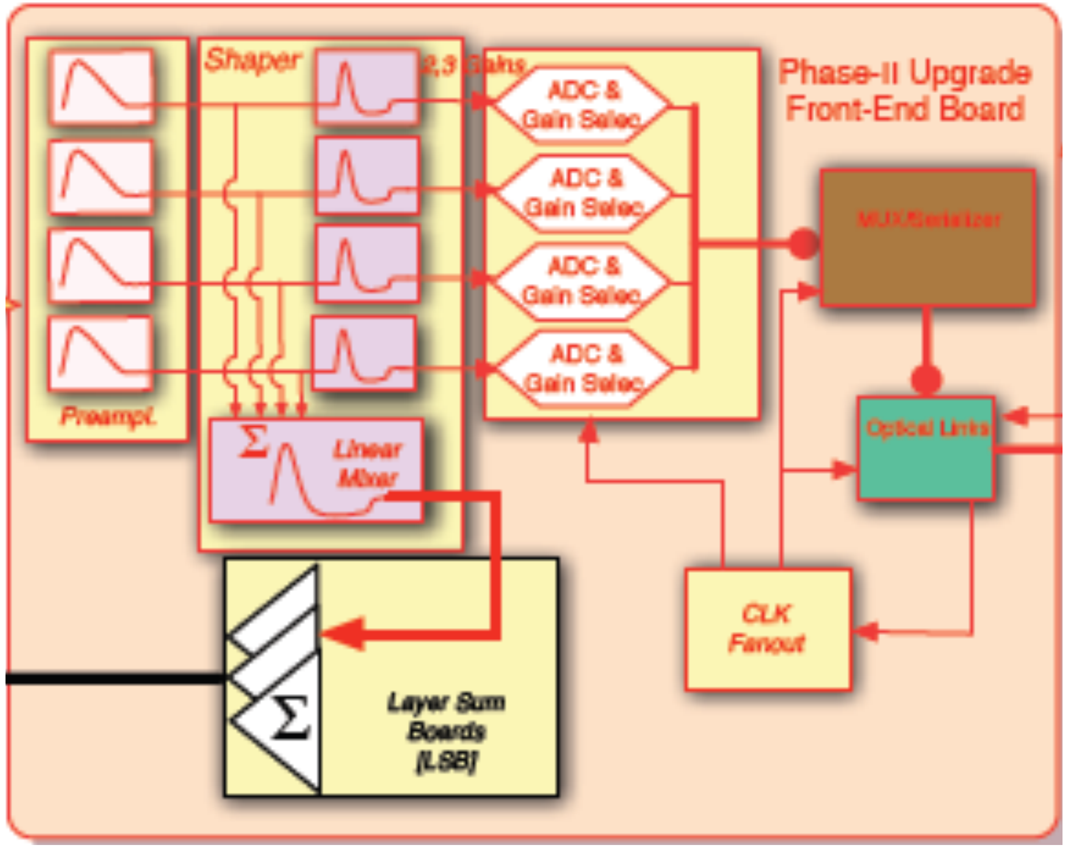
Phase II LAr Readout Architecture





LAr FE Electronics

- As in original construction, US groups proposing to take lead responsibility for LAr FE readout electronics, with deliverables including:
  - Rad-tol ASICs:
    - Preamp/shaper (BNL, U Penn)
    - ADC (Columbia)
    - High speed serializer (SMU)
  - Optical link components (SMU)
  - FEB2 (Columbia)



- Apart from a complementary French PA/shaper effort, no non-US groups are currently pursuing these tasks

LAr Electronics Core Costs (from SD)

Table 16. CORE costs for the new LAr Calorimeter readout. *(Comment: LPPR and FELIX/TTC costs still in review.)*

WBS ID	Upgrade Item	All Cost Scenarios [kCHF]
3.1	**LAr Readout Electronics**	**31,394**
3.1.1	**LAr Front-end Electronics**	**20,427**
3.1.1.1	Front-end Boards (FEB-2)	9,743
3.1.1.2	Optical fibres and fibre plant	4,306
3.1.1.3	Front-end power distribution system	3,123
3.1.1.4	HEC LVPS	622
3.1.1.5	Calibration System	2,484
3.1.1.6	Shipping and Logistics	150
3.1.2	**LAr Back-end Electronics**	**10,967**
3.1.2.1	LAr Pre-processor Boards (LPPR)	10,212
3.1.2.2	Transition modules	122
3.1.2.3	ATCA shelves	66
3.1.2.4	ATCA switches	76
3.1.2.5	Server PC	22
3.1.2.6	Controller PC	8
3.1.2.7	FELIX/TTC System	460

Status of FE Electronics Cost Estimate

Fund	WBS	Tag	Description	AY k$	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	Total	FY20-FY24
	6.4.2		FE Electronics	Total	928.642	1,314.644	1,576.659	2,437.903	5,355.365	4,426.139	2,704.040	1,522.983	-	20,266.374	16446.430
				Labor	910.642	1,256.644	1,409.759	1,588.503	2,091.965	1,679.139	1,176.040	999.983	-	11,112.674	7535.630
				Material	30.000	40.000	108.200	796.200	3,206.200	2,720.000	1,510.000	510.000	-	8,920.600	8742.400
				Travel	13.000	18.000	33.700	53.200	57.200	27.000	18.000	13.000	-	233.100	168.400
				CORE										-	0.000
				FTEs	6.040	7.840	9.640	11.720	13.660	12.570	7.580	6.500	-	75.550	52.030
NSF	6.4.2.1		LArFE_Columbia	Total	381.902	683.897	680.773	1,402.693	2,548.104	2,501.081	2,432.341	1,460.162	-	12,090.952	10344.381
				Labor	381.902	643.897	630.773	679.693	910.104	931.081	927.341	955.162	-	6,059.952	4403.381
				Material	20.000	30.000	20.000	708.000	1,628.000	1,560.000	1,500.000	500.000	-	5,966.000	5896.000
				Travel	5.000	10.000	5.000	15.000	10.000	10.000	5.000	5.000	-	65.000	45.000
				CORE	-	-	-	-	-	-	-	-	-	-	0.000
				FTEs	2.300	3.600	4.400	4.400	6.000	5.900	5.500	5.500	-	37.600	27.300
NSF	6.4.2.2		LArFE_Penn	Total	75.454	77.717	82.549	99.942	864.595	362.195	30.032	-	-	1,592.483	1356.763
				Labor	75.454	77.717	80.049	95.442	656.095	208.195	30.032	-	-	1,222.983	989.763
				Material	-	-	2.000	2.000	202.000	150.000	-	-	-	356.000	354.000
				Travel	-	-	0.500	2.500	6.500	4.000	-	-	-	13.500	13.000
				CORE	-									-	0.000
				FTEs	0.240	0.240	0.240	0.320	2.160	1.170	0.080	-	-	4.450	3.730
DOE	6.4.2.3		LArFE_BNL	Total	270.156	280.962	291.265	302.916	-	-	-	-	-	1,145.300	302.916
				Labor	270.156	280.962	291.265	302.916	-	-	-	-	-	1,145.300	302.916
				Material										-	0.000
				Travel										-	0.000
				CORE										-	0.000
				FTEs	1.500	1.500	1.500	1.500	-	-	-	-	-	6.000	1.500
NSF	6.4.2.4		LArFE_SMU	Total	146.687	216.530	465.409	574.530	1,883.649	1,502.615	180.152	-	-	4,969.572	4140.945
				Labor	146.687	216.530	369.009	470.630	484.749	497.615	175.152	-	-	2,360.372	1628.145
				Material	-	-	76.200	76.200	1,366.200	1,000.000	-	-	-	2,518.600	2442.400
				Travel	-	-	20.200	27.700	32.700	5.000	5.000	-	-	90.600	70.400
				CORE	-	-	-	-	-	-	-	-	-	-	0.000
				FTEs	1.000	1.500	2.500	4.500	4.500	4.500	1.000	-	-	19.500	14.500
NSF	6.4.2.5		LArFE_UTAustin	Total	54.443	55.537	56.663	57.823	59.017	60.248	61.515	62.821	-	468.067	301.424
				Labor	36.443	37.537	38.663	39.823	41.017	42.248	43.515	44.821	-	324.067	211.424
				Material	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	-	80.000	50.000
				Travel	8.000	8.000	8.000	8.000	8.000	8.000	8.000	8.000	-	64.000	40.000
				CORE										-	0.000
				FTEs	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	-	8.000	5.000

FE Electronics at Columbia

- Two main tasks:
  - Develop ADC chip in 65 nm CMOS
  - Develop FEB2
- JP working on BOE (draft so far is on Indico)
  - FEB M&S estimates based on FEB, Phase I LTDB
  - ADC M&S estimates based on pricing info for 65 nm; assume ADC produced with PA/shaper and serializer on same wafers to avoid multiple mask charges
  - Labor estimates developed bottoms-up based on previous projects (including FEB, 130 nm ADC for Phase I)
- Work similar to what we did in original construction (SCA and FEB development), for which the Actual Costs were M&S 4352k + Labor 4217k for a total of 8569k
  - Comparison supports estimate of total costs of M&S 5896k + Labor 4403k

PA/shaper chip

- Effort led by BNL, with collaboration from U Penn (Mitch Newcomer), to develop and produce PA/shaper chip in 65 nm CMOS
- Bottoms-up manpower estimates from Hong, Mitch
- M&S production costs assigned to U Penn, to maximize NSF scope
    - Mostly packaging charges, since NRE + wafer production contained within ADC costs
- Still need someone to start working on BOE (Hong?)

FE Electronics at SMU

- SMU
  - Develop serializer chip in 65 nm CMOS, plus optical link components
  - Manpower estimate made bottoms-up
  - M&S (and manpower) estimates profit from Phase I work
    - See next slide

  - J. Ye working on BOE (first draft to be provided this week)

FE Electronics at SMU (cont'd)

From yejb@physics.smu.edu
Subject **Re: status of cost estimate**
To John Parsons

assumptions:

1, wafer production (NRE + wafer itself) and dicing are not from SMU.
2, SMU takes care of the serializer packaging (to QFN) and OTx assembly.
3, 1524 FEBs with 8% FEB spares and 8% component spares
4, 128 detector channels on each FEB, each channel runs at 2 gains at 14-bits and 80 MSPS.
5, each detector channel data 2.24 Gbps. Assume 30% framing and FEC (GBT-like), this gives 2.912 Gbps/channel, 372.7 Gbps/FEB
6, 10 Gbps per fiber, and two serializers in one QFN package: 20 serializer chips per FEB, and 35,357 serializer chips total.
7, using a 12 array optical module, use 10 channels with 2 as spares, this gives 4 OTx modules per FEB, and 7,072 OTx modules total.

For the serializer, the QFN packaging (using numbers we quoted for ph-1 LOCx2)
NRE: $1,500
Tooling: $4,000
QFN frame $2,000/3,000, Tray $200/3,000, will need 12 sets: $2,200 * 12 = $26,400
Packaging lot: $1,000/200, will need 177 lots: $177,000
A total of $208,900 for the serializer chip packaking.

For OTx, based on past POs:
MOI: $6.50
Prizm: $50 (a guess at this moment, this one was purchased through FNAL)
VCSEL (12 lane array): $104.20
PCB: $5
ZA8 (connector and accessaries): $11.67 + $1.5
Assembly (wire bond): $1,000/25 = $40

This gives a total of $218.87 for each OTx, and a total of $1,547,848.64 for the whole system.

the control link (price from CERN and Versatile Link):
GBTx $55
GBT-SCA $26.4
VTRx $220

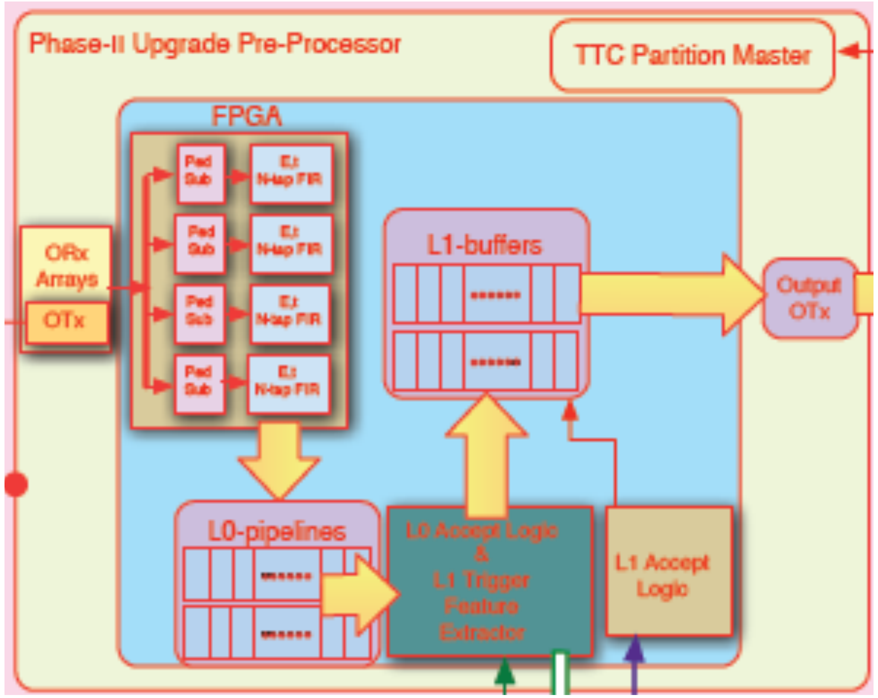
Assume one control link per FEB, this gives a total cost of $532,826.97

The grand total, excluding the fiber adaptor on the front panel, is $2,289,575.61

FE Electronics at UT Austin

- Tim Andeen, who has been very active in Phase I ADC effort as a Columbia postdoc the past 5 years, is a new Asst. Prof. at UT Austin
- Tim would like to continue close collaboration with Columbia
- Profiting from the experience he gained at Columbia, we discussed possibility his group could help with chip testing, both performance and irradiation
  - He is looking into possibility to get some EE or tech manpower, so that he could build his own test jigs; otherwise, we could provide them
  - His university is supportive
- Put in 1 FTE plus modest M&S and travel to support testing role
- Need to get Tim started on BOE

LAr BE Electronics



- BE construction responsibilities for Phase II are so far less advanced than for FE
  - Current RODs were built by European collaborators, and considerable interest exists there for a similar role for the LPPR in Phase II
  - US groups are playing significant roles in Phase I LDPS, and will bring this expertise to development of BE electronics for Phase II
- BE electronics was not included in US cost/manpower estimates made in 2014, so needed to start new costing effort
- On Sept 24, I held a mtg at CERN in which the various US groups were invited to present their proposed BE contributions, and estimates of needed resources
  - Presentations were made by U Arizona, BNL, Stony Brook and MSU+Oregon
  - Initial estimates were prepared based on these inputs and subsequent followups, and are now included in the spreadsheet

LAr BE Electronics

- In recent discussions I had with Wade and Stephanie, we all agreed that efforts of MSU and Oregon would be more sensibly hosted within TDAQ (they are in fact included in the TDAQ WBS shown during our last Phase II mgmt mtg)
  - They are included in my spreadsheet today, including their estimated costs, but these items will be removed in future
  - Removing the MSU and Oregon contributions reduces LAr BE total construction costs (ie. FY20-FY24) from $7993k to $4281k

- BE effort is continued collaboration of Stony Brook, Arizona, BNL
  - For DOE/NSF split issues, M&S listed under Stony Brook, and BNL contributions listed under separate WBS for System Integration
  - Costing uses experience from this group's development of the LDPS for Phase I
  - John H., Kj, Hong are working together to prepare BOE

LAr BE Cost Estimate

Fund	WBS	Tag	Description	AY k$	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	Total	FY20-FY24
NSF	**6.4.3.1**		**LArBE_Arizona**	**Total**	**42.889**	**43.876**	**44.892**	**90.874**	**93.300**	**95.799**	**98.373**	**101.024**	**-**	**611.028**	479.371
				Labor	32.889	33.876	34.892	80.874	83.300	85.799	88.373	91.024	-	531.028	429.371
				Material	10.000	10.000	10.000	10.000	10.000	10.000	10.000	10.000	-	80.000	50.000
				Travel	-	-	-	-	-	-	-	-	-	-	0.000
				CORE	-									-	0.000
				FTEs	0.250	0.250	0.250	0.950	0.950	0.950	0.950	0.950	-	5.500	4.750
NSF	**6.4.3.5**		**LArBE_SB**	**Total**	47.902	199.339	200.820	301.051	305.582	1,060.250	1,065.057	1,070.009	-	*4,250.010*	3801.948
				Labor	47.902	49.339	50.820	151.051	155.582	160.250	165.057	170.009	-	*950.010*	801.948
				Material	-	150.000	150.000	150.000	150.000	900.000	900.000	900.000	-	*3,300.000*	3000.000
				Travel										-	0.000
				CORE										-	0.000
				FTEs	0.250	0.250	0.250	0.950	0.950	0.950	0.950	0.950	-	*5.500*	4.750

System Integration

- As in original construction, BNL is planning to be involved in testing and integration of both FE and BE electronics
  - FEB2 precision analog testing (after functional test at Columbia)
  - Full FE crate system test (used to qualify FE system before PRR)
  - Contribution to development (with SB, Az) of BE electronics
  - Tests to integrate and test the FE and BE electronics together

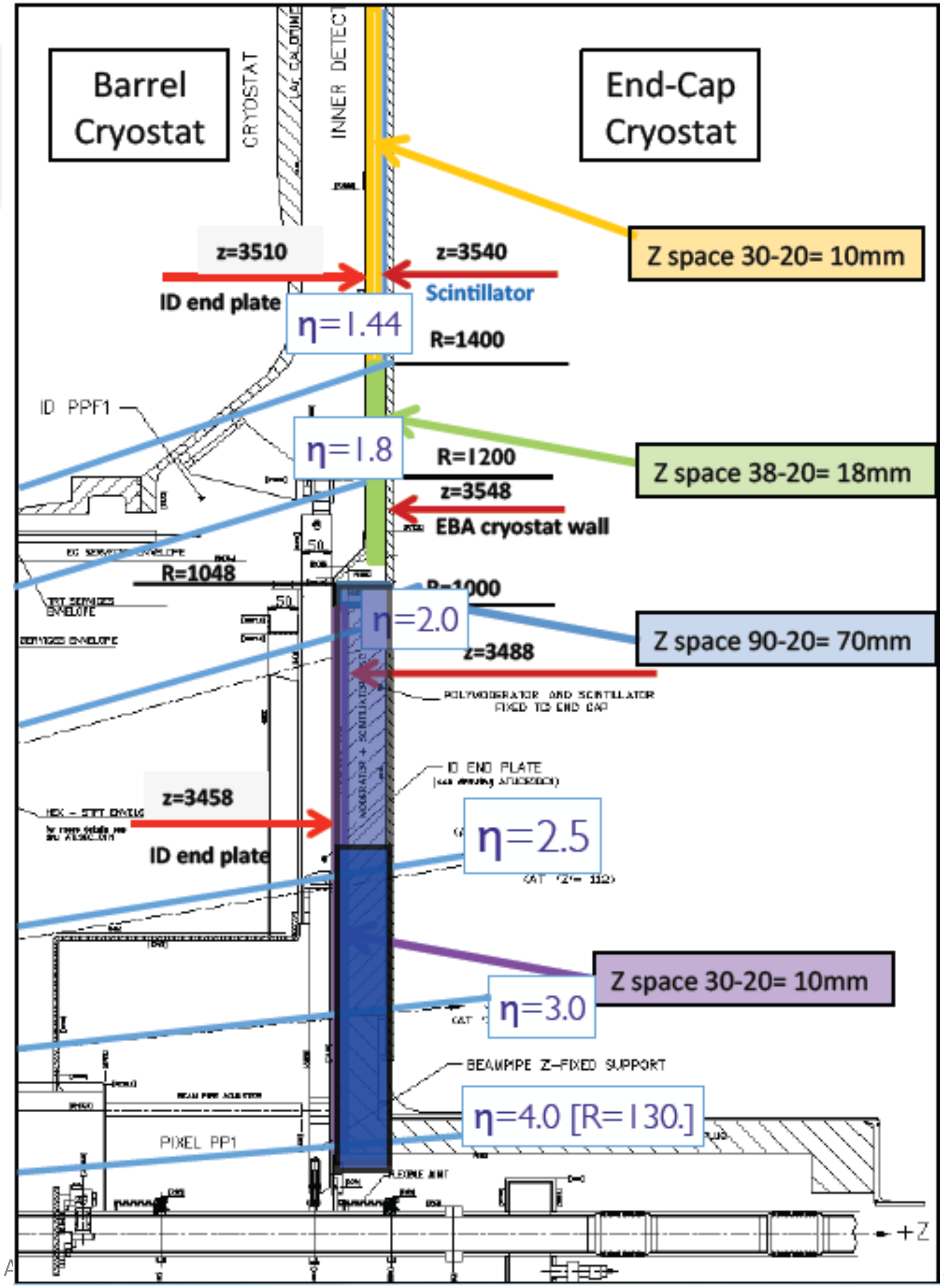
- To maintain clean DOE/NSF split, have separated these BNL activities and grouped them into a separate task (task 4 from a previous slide) with its own (DOE-funded) WBS
  - Following this strategy, the LAr FE and BE deliverables (apart from BNL effort on PA/shaper chip) can all fall under NSF scope
  - M&S costs placed as much as possible under university group (eg. U Penn for PA/shaper, SB for BE)
  - Manpower estimates from Hong (BOE not available yet)

System Integration Cost Estimate

Fund	WBS	Tag	Description	AY k$	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	Total	FY20-FY24
DOE	6.4.4		System Integration	Total	92.574	96.277	482.871	797.077	820.990	845.619	870.988	897.118	-	4,903.514	4,231.792
				Labor	92.574	96.277	482.871	797.077	820.990	845.619	870.988	897.118	-	4,903.514	4231.792
				Material	-	-	-	-	-	-	-	-	-	-	0.000
				Travel	-	-	-	-	-	-	-	-	-	-	0.000
				CORE	-									-	0.000
				FTEs	0.500	-	2.500	4.500	4.500	4.500	4.500	4.500	-	25.500	22.500

HGTD

- Scoping Document includes possible new "4D" detector in space of current MTBS
  - Δz = 60 mm detector could cover η of 2.4 – 4.1 (5.0)
- Aiming for time res'n of 30-50 ps and spatial granularity of 1-100 mm^2
- Possibly multiple layers, if also used as preshower
- Synergy with possible Si/Cu miniFCAL (and also CMS)
- More MC studies needed to optimize design and evaluate ability to use timing to reject pileup, select PV, …



HGTD Core Costs (from SD)

Table 20. CORE costs for a High-Granularity Timing Detector in the Reference cost scenario. No Timing Detector is being planned at this stage for the Medium and Low cost scenarios.

WBS ID	Upgrade Item	Reference [kCHF]
3.3	**HGTD**	**4,558**
3.3.1	Sensors and on-detector active electronics	1,921
3.3.2	Front-end readout	1,988
3.3.3	Back-end readout	450
3.3.4	Services	200

- A number of US institutions have expressed interest in HGTD
  - Spreadsheet includes efforts presented so far (UCSC, U Penn, U Iowa, SLAC)
  - It is possible (likely?) that more groups will come forward still
- Need to identify person to lead effort to prepare BOE (Ariel Schwartzman?)
- UCSC hosting a 1-day mtg on fast timing electronics on Nov. 9, which is a good opportunity to talk together about future organization of effort

HGTD Cost Estimate

Fund	WBS	Tag	Description	AY k$	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	Total	FY20-FY24
	6.4.5		HGTD	Total	338.221	418.666	565.120	698.952	2,424.083	1,135.468	474.397	354.696	-	6,409.603	5,087.596
				Labor	338.221	418.666	432.620	544.452	1,115.583	681.468	374.397	354.696	-	4,260.103	3070.596
				Material	-	-	132.000	152.000	1,302.000	450.000	100.000	-	-	2,136.000	2004.000
				Travel	-	-	0.500	2.500	6.500	4.000	-	-	-	13.500	13.000
				CORE	-									-	0.000
				FTEs	1.240	1.740	1.740	2.320	4.660	3.670	2.080	2.000	-	19.450	14.730
NSF	6.4.4.1		HGTD_UCSC	Total	-	**68.959**	**121.027**	**173.158**	**492.742**	**195.524**	**98.390**	**101.342**	-	**1,251.141**	1061.156
				Labor	-	**68.959**	**71.027**	**73.158**	**92.742**	**95.524**	**98.390**	**101.342**	-	601.141	461.156
				Material	-	-	**50.000**	**100.000**	**400.000**	**100.000**	-	-	-	650.000	600.000
				Travel	-	-	-	-	-	-	-	-	-	-	0.000
				CORE	-									-	0.000
				FTEs	-	**0.500**	**0.500**	**0.500**	**1.000**	**1.000**	**1.000**	**1.000**	-	5.500	4.500
NSF	6.4.4.2		HGTD_Penn	Total	**75.454**	**77.717**	**82.549**	**99.942**	**864.595**	**362.195**	**30.032**	-	-	*1,592.483*	1356.763
				Labor	75.454	77.717	80.049	95.442	656.095	208.195	30.032	-	-	*1,222.983*	989.763
				Material	-	-	2.000	2.000	202.000	150.000	-	-	-	*356.000*	354.000
				Travel	-	-	0.500	2.500	6.500	4.000	-	-	-	*13.500*	13.000
				CORE	-									-	0.000
				FTEs	0.240	0.240	0.240	0.320	2.160	1.170	0.080	-	-	*4.450*	3.730
DOE	6.4.4.3		HGTD_SLAC	Total	**134.017**	**139.378**	**224.953**	**150.751**	**634.892**	**138.939**	-	-	-	*1,422.929*	924.582
				Labor	134.017	139.378	144.953	150.751	134.892	138.939	-	-	-	*842.929*	424.582
				Material	-	-	80.000	-	500.000	-	-	-	-	*580.000*	500.000
				Travel	-	-	-	-	-	-	-	-	-	-	0.000
				CORE	-									-	0.000
				FTEs	0.500	0.500	0.500	0.500	0.500	0.500	-	-	-	*3.000*	1.500
NSF	6.4.4.4		HGTD_Iowa	Total	**128.750**	**132.613**	**136.591**	**275.102**	**431.855**	**438.810**	**345.975**	**253.354**	-	2,143.049	1745.096
				Labor	**128.750**	**132.613**	**136.591**	**225.102**	**231.855**	**238.810**	**245.975**	**253.354**	-	1,593.049	1195.096
				Material	-	-	-	**50.000**	**200.000**	**200.000**	**100.000**	-	-	550.000	550.000
				Travel	-	-	-	-	-	-	-	-	-	-	0.000
				CORE	-										
				FTEs	**0.500**	**0.500**	**0.500**	**1.000**	**1.000**	**1.000**	**1.000**	**1.000**	-	6.500	5.000

HGTD Discussion

- For a number of reasons, it was agreed within international ATLAS (and therefore also US ATLAS) to manage HGTD within LAr

- It is clear that the highest priorities for LAr for Phase II must be dealing with the FCAL problems at high lumi (eg. replace with sFCAL) and developing a new electronic readout (both FE and BE)
  - Without these upgrades, the LAr calorimeters will not perform as needed in the HL-LHC phase

- Given limited resources, the HGTD will always come out at the bottom of the priorities, if simply compared with the other LAr needs
  - If the US wants to participate in HGTD, we need to have separate “guidance” for this detector
  - ie. HGTD can be managed within LAr, but needs separate allocation

LAr High Level Cost Summary

6.4 SUBSYTEM LAr: CONSTRUCTION COSTS

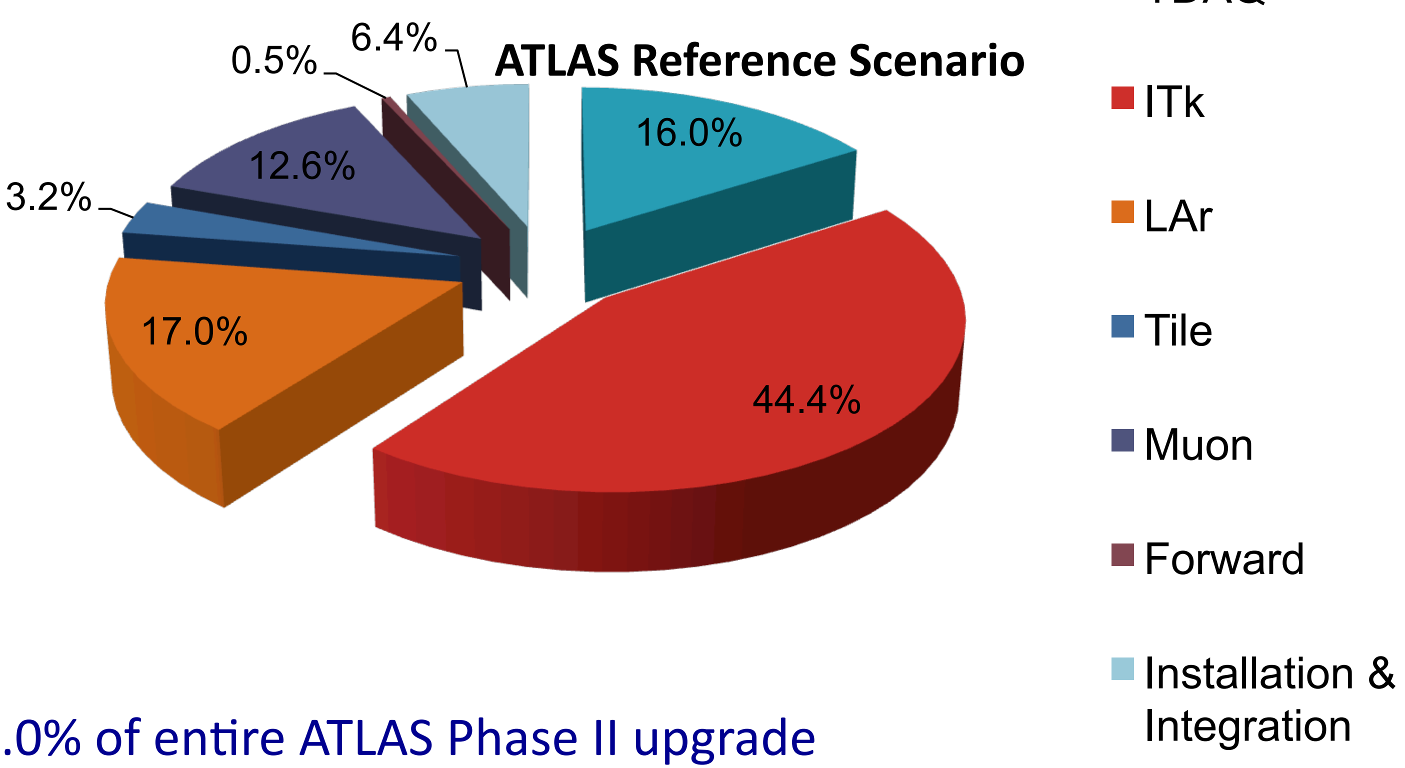
Fund	WBS	Tag	Description	AY k$	FY17	FY18	FY19	FY20	FY21	FY22	FY23	FY24	FY25	Total	FY20-FY24
	6.4		Subsystem LAr	Total	2,016.814	2,802.523	3,734.796	6,697.801	11,515.626	8,935.011	6,518.352	5,166.023	-	47,386.944	38832.812
				Labor	1,963.814	2,539.523	3,060.396	4,051.901	5,228.726	4,514.011	3,696.352	3,378.023	-	28,432.744	20869.012
				Material	60.000	240.000	605.200	2,568.200	6,208.200	4,380.000	2,795.000	1,765.000	-	18,621.600	17716.400
				Travel	18.000	23.000	44.200	77.700	78.700	41.000	27.000	23.000	-	332.600	247.400
				CORE	-									-	0.000
				FTEs	11.520	14.620	16.020	22.190	27.220	26.490	19.260	15.700	-	153.020	110.860
	6.4.1		FCAL	Total	128.621	169.336	157.838	1,738.827	1,864.196	700.062	538.673	232.616	-	5,530.168	5074.374
				Labor	103.621	144.336	92.838	256.827	309.196	390.062	329.673	152.616	-	1,779.168	1438.374
				Material	20.000	20.000	55.000	1,460.000	1,540.000	300.000	200.000	70.000	-	3,665.000	3570.000
				Travel	5.000	5.000	10.000	22.000	15.000	10.000	9.000	10.000	-	86.000	66.000
				CORE	-									-	0.000
				FTEs	0.900	1.200	0.800	2.750	3.500	4.850	4.200	1.800	-	20.000	17.100
	6.4.2		FE Electronics	Total	928.642	1,314.644	1,576.659	2,437.903	5,355.365	4,426.139	2,704.040	1,522.983	-	20,266.374	16446.430
				Labor	910.642	1,256.644	1,409.759	1,588.503	2,091.965	1,679.139	1,176.040	999.983	-	11,112.674	7535.630
				Material	30.000	40.000	108.200	796.200	3,206.200	2,720.000	1,510.000	510.000	-	8,920.600	8742.400
				Travel	13.000	18.000	33.700	53.200	57.200	27.000	18.000	13.000	-	233.100	168.400
				CORE	-									-	0.000
				FTEs	6.040	7.840	9.640	11.720	13.660	12.570	7.580	6.500	-	75.550	52.030
	6.4.3		BE Electronics	Total	528.757	803.600	952.308	1,025.041	1,050.992	1,827.722	1,930.254	2,158.611	-	10,277.285	7,992.620
				Labor	518.757	623.600	642.308	865.041	890.992	917.722	945.254	973.611	-	6,377.285	4592.620
				Material	10.000	180.000	310.000	160.000	160.000	910.000	985.000	1,185.000	-	3,900.000	3400.000
				Travel	-	-	-	-	-	-	-	-	-	-	0.000
				CORE	-									-	0.000
				FTEs	3.500	4.000	4.000	5.400	5.400	5.400	5.400	5.400	-	38.500	27.000
	6.4.4		System Integration	Total	92.574	96.277	482.871	797.077	820.990	845.619	870.988	897.118	-	4,903.514	4,231.792
				Labor	92.574	96.277	482.871	797.077	820.990	845.619	870.988	897.118	-	4,903.514	4231.792
				Material	-	-	-	-	-	-	-	-	-	-	0.000
				Travel	-	-	-	-	-	-	-	-	-	-	0.000
				CORE	-									-	0.000
				FTEs	0.500	-	2.500	4.500	4.500	4.500	4.500	4.500	-	25.500	22.500
	6.4.5		HGTD	Total	338.221	418.666	565.120	698.952	2,424.083	1,135.468	474.397	354.696	-	6,409.603	5,087.596
				Labor	338.221	418.666	432.620	544.452	1,115.583	681.468	374.397	354.696	-	4,260.103	3070.596
				Material	-	-	132.000	152.000	1,302.000	450.000	100.000	-	-	2,136.000	2004.000
				Travel	-	-	0.500	2.500	6.500	4.000	-	-	-	13.500	13.000
				CORE	-									-	0.000
				FTEs	1.080	1.580	1.580	2.320	4.660	3.670	2.080	2.000	-	18.970	14.730

Cost Issues and Discussion

- Spreadsheet has total US construction cost (FY20-FY24) of $38.8M
- Moving MSU+Oregon to TDAQ, this reduces to $35.1M
- How to handle the various scenarios that exist?
  - Assume both sFCAL and HGTD built: $35.1M
  - Assume sFCAL built, but NOT HGTD: $30.0M
  - Assume NO sFCAL, no MiniFCAL and no HGTD: $25.0M

Allocation?

❖ How should US allocations for each subsystem be set?



❖ LAr is 17.0% of entire ATLAS Phase II upgrade

- Hal's slides from the JOG show 134M for subsystem scope (plus contingency, project mgmt, etc. to get grand total of $230M)
- A 17% fraction would correspond to $22.8M (cf. ~19.6M from JOG mtg)

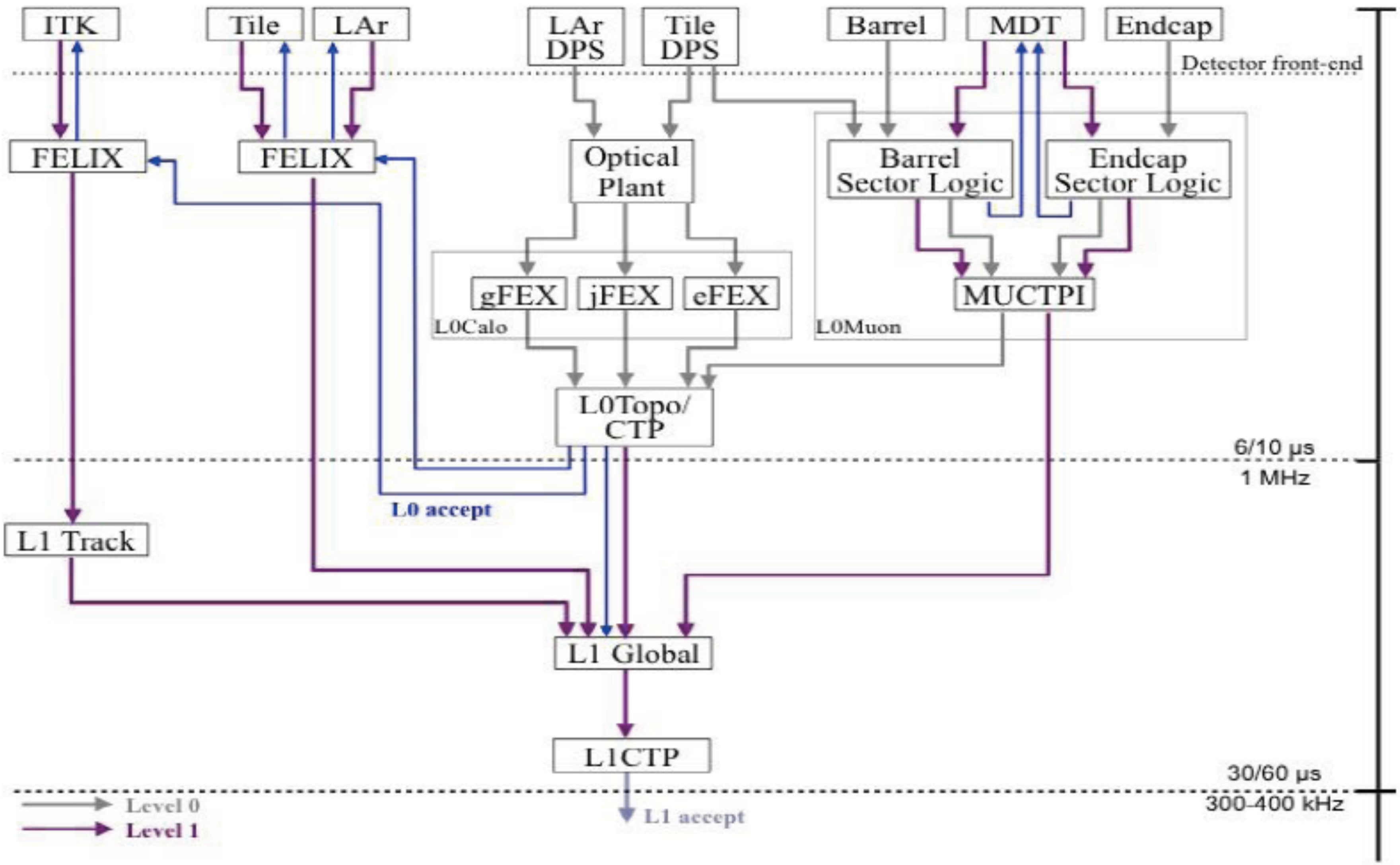
  (Also, US LAr request is a similar fraction of the total US requests)

Prioritization

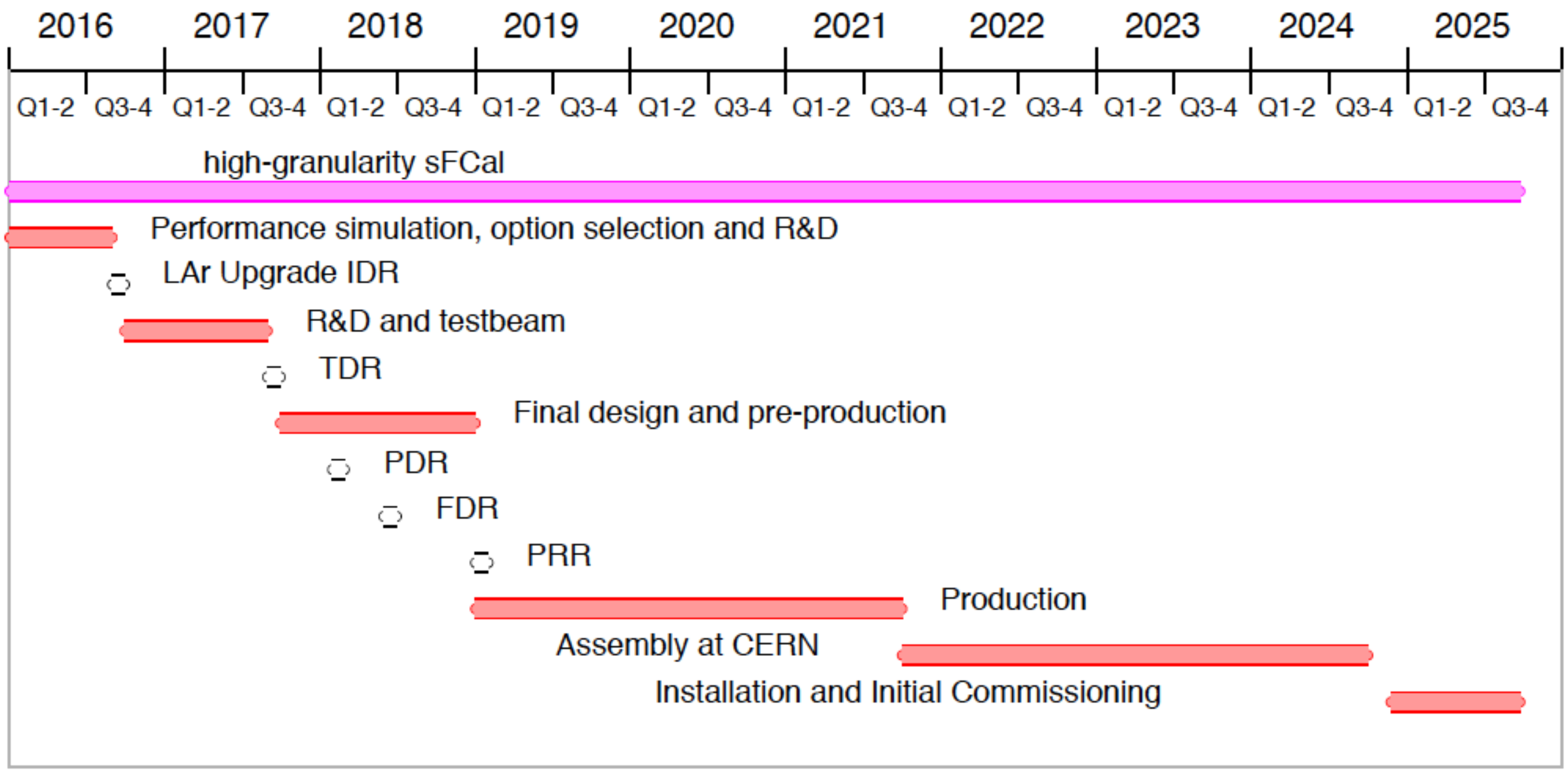
- The spreadsheet on Indico includes a “Potential Reductions” sheet that itemizes possible descoping
- Included are 2 lists, one providing a total reduction of ~12.8M and the second, extended to include even much more damaging descopings, that would provide a total reduction of ~18.9M
  - In the Reference scenario from the SD (where both sFCAL and HGTD are included in the construction) these would reduce US costs to 25.5M (19.4M)
- Guidance of ~19.6M shown at JOG would require adopting all of “Extended Descoping” list, causing terrible damage to the program
  - Additional losses include: no FCAL cold electronics, no PA/shaper production, X2 less BE manpower, X2 less System Integration manpower, no HGTD contribution
- We need the LAr guidance to more reasonably reflect the fractional value and cost of the LAr upgrade as part of the overall Phase II upgrade

Backup Slides

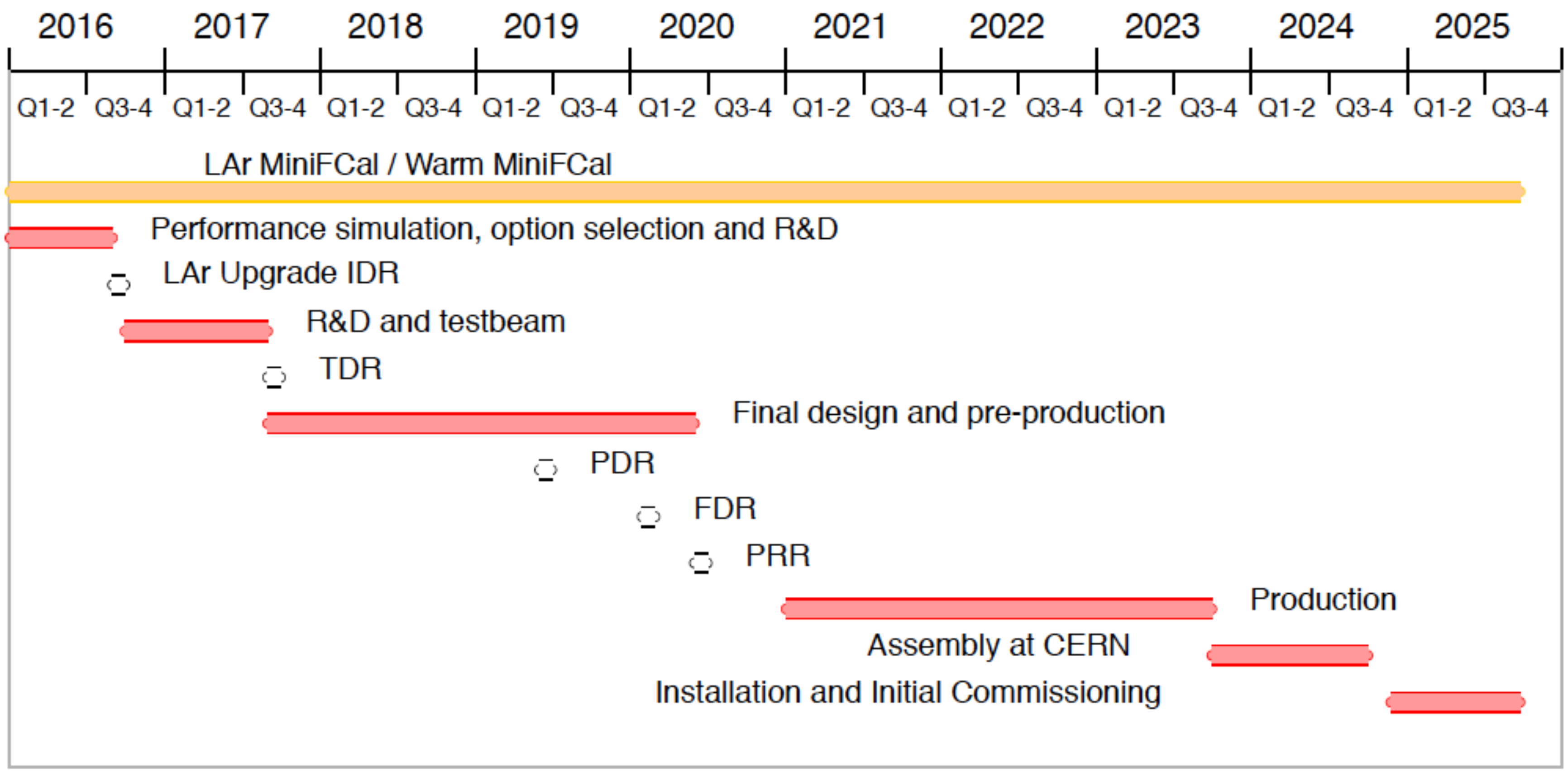
Phase II TDAQ Architecture



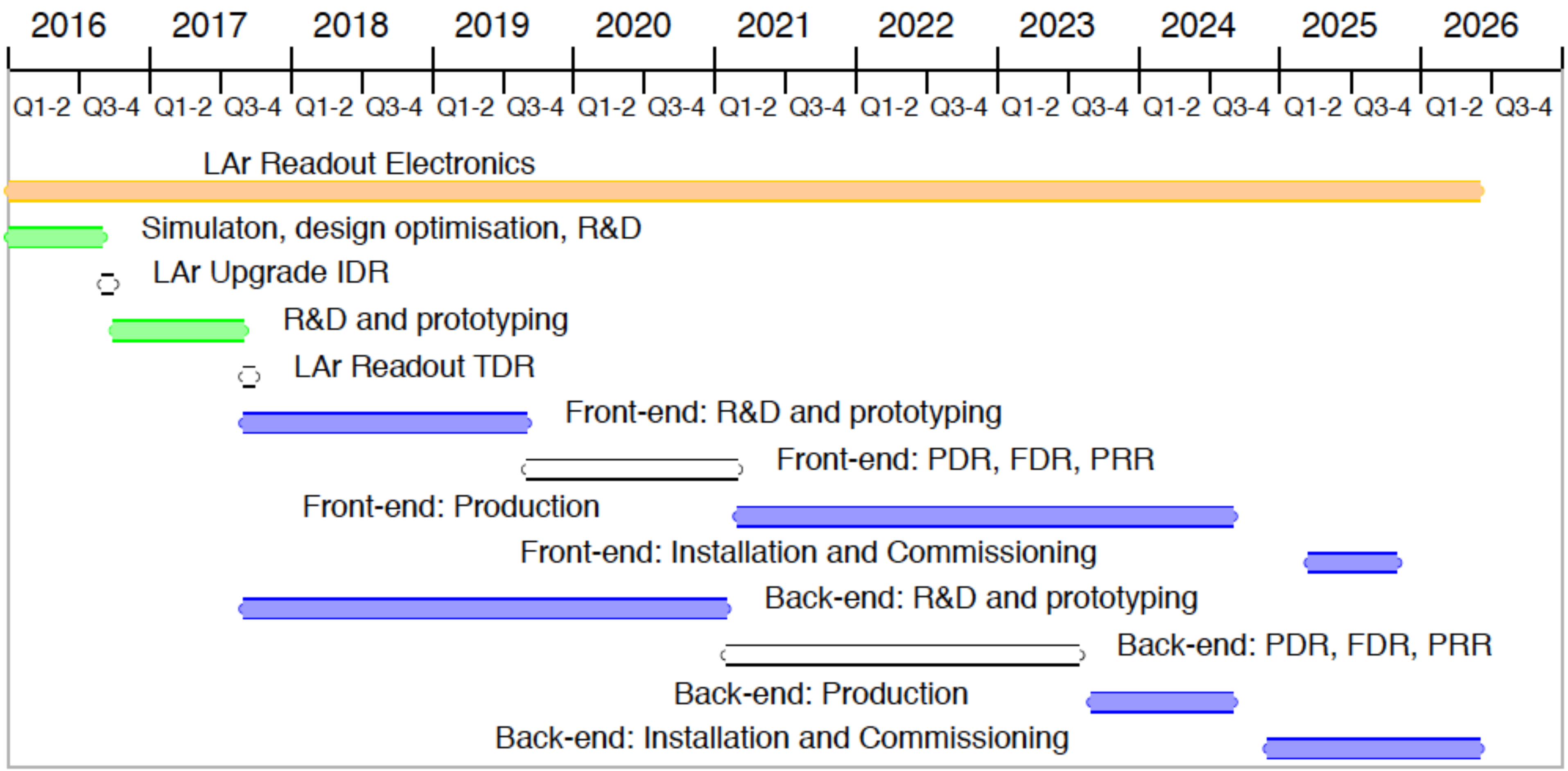
sFCAL Schedule (from SD)



MiniFCAL Schedule (from SD)



LAr Electronics Schedule (from SD)



HGTD Schedule (from SD)